PB-217 418

SEDIMENT PRODUCTION RATING, UMPQUA BASIN, OREGON

W. E. Bullard

Public Health Service
Portland, Oregon

January 1962

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

REGIONAL INFORMATION OFFICE

PB 217 418

WORKING PAPER NO. 9

COLUMBIA RIVER BASIN PROJECT
FOR WATER SUPPLY AND WATER QUALITY MANAGEMENT

SEDIMENT PRODUCTION RATING
UMPQUA BASIN
OREGON

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

Jan. 1962

Prepared by: W. E. Bullard

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Region IX

Division of Water Supply and Pollution Control
Room 570 Pittock Block
Portland 5, Oregon

12

SEDIMENT PRODUCTION RATING
UMPQUA BASIN
OREGON

INTRODUCTION

The sediment production rating is an attempt to assess a major impact of land condition, use, and management in a watershed on the quality of water produced by that watershed. The rating for the Umpqua Basin was done as a part of the Columbia Water Resources Project. The first work of the kind was done on the Umpqua Basin for five reasons: - information on the area was desired to supplement a report due the Corps of Engineers within the year; Douglas County (practically synonymous with the Umpqua Basin as to area) had collected four and a half years of bi-weekly suspended sediment sampling data for ten stations on the Umpqua River and its tributaries; the Forest Service pilot forest soils survey in the South Umpqua River Watershed provided detailed soils information for part of the mountain area; the hoped-for information on rate of sediment production might prove useful in connection with the studies on the Umpqua River estuary; and the known range of erosion/sedimentation conditions was believed to represent the extremes to be found in and west of the Cascade Range.

SUMMARY AND CONCLUSIONS

Over all, the Umpqua Basin is rated "moderate" in sediment production. Broadly interpreted, the sediment production ratings used correspond to average sediment loads in streamflow as follows:

Rating Class	Average Sediment Load in ppm
Slight	under 50
Low	50 to 150
Moderate	150 to 500
High	500 to 1,500
Very High	1,500 plus

Thus the "moderate" rating indicates for the 6,700,000 acre-feet (1) average annual water yield of the Basin an average sediment movement between 1,000 and 3,000 acre-feet; or in other terms, from 350 to 1,100 tons per square mile of contributing watershed.

Highest rates of sediment production are found in the southern part of the basin, in the upper South Umpqua River and Cow Creek Watersheds. Both the Days Creek and the upper Cow Creek Watersheds were rated "Very High."

Low rates are found on the western side of the main Umpqua River and in the North Umpqua River Watershed, with the lowest in the pumice-blanketed upper North Umpqua River Watershed above the dams of the California-Oregon Power Company.

From the standpoint of natural instability, the "red hill" clayey soil areas of the central part of the basin provide the greatest erosion/sedimentation potential. These soils are typical of much of the Lookingglass, Calapooya, and Elk Creek drainages.

Considering the effects of land use, the deeply weathered granodiorites of the Cow Creek Watershed and the green tuffs and breccias of the South Umpqua River Watershed produce the most sediments.

DESCRIPTION OF THE BASIN

The Umpqua Basin is irregularly triangular in shape, 115 miles long from the crest of the Cascade Range west to the Pacific Ocean, and 75 miles wide north to south across the center. Basin area is approximately 4,560 square miles (1). Elevations range from sea-level to above 9,000 feet atop Mt. Thielsen at the head of the North Umpqua River. Topography in the mountain areas both in the Cascades and in the Coast Range is rough with narrow, steep-walled valleys except in the central part of the basin where rolling hills dominate the landscape.

Drainage is westerly from the Cascade Range to the Pacific Ocean. The North Umpqua and South Umpqua Rivers meet in the center of the basin to form the Umpqua which winds north and then west through the Coast Range to Winchester Bay. Smith River in the northernmost part of the basin is tributary to the Umpqua at the head of the Bay. Mill Creek from the Coast Range on the south, and Elk Creek and Calapooya Creek from the Cascade foothills on the east are major tributaries of the main Umpqua River. Olallie Creek, Cow Creek, Elk Creek, and Jackson Creek are major tributaries of the South Umpqua on the southern edge of the basin. Little River, Rock Creek, Steamboat Creek, Fish Creek, Clearwater River, and Lake Creek are the principal tributaries of the North Umpqua River in the Cascades on the eastern side of the basin.

Stream gradients vary widely. The upper half of the North Umpqua has a gradient of 83 feet per mile; the lower half, 19 feet per mile. Cow Creek has a gradient of 23 feet per mile. The upper South Umpqua has a gradient of 42 feet per mile; the central part, 13 feet per mile; and the lower (below Cow Creek), 6 feet per mile. The main Umpqua has a gradient of about 4 feet per mile.

Geology is mixed. Most of the Coast Range area in the lower main Umpqua and Smith River Watersheds is underlain by interbedded shales and hard sandstones and conglomerates of the Eocene Tyee formation. The soils are for the most part sandy clay loams (2). Altered lava, tuff, breccias and shales of the Jurassic Rogue River and associated formations underlie the central and foothill areas of the basin. The unstable "red hill" clay soil is typical of much of this central portion. Eocene volcanic rocks underlie most of the Cascade Mountain section of the basin. Soils on these rocks have a fairly high erosion potential. The recent volcanic rocks and pumice of the uppermost eastern part of the basin support somewhat more

stable soils, though pumice can erode readily if disturbed. The southern part of the basin in the Klamath-Siskiyou geologic province is underlain by granites, metamorphosed sediments, and serpentines. Soils are variable on these rocks, but all are unstable and have a very high erosion potential.

Climate is mild, though varying with elevation. Summers are warm and fairly dry. Winters are cool and wet, with most precipitation as rain except in the higher easternmost part of the basin. Recorded temperatures range from 6°F to 109°F. Average length of growing season in the valleys is 190 days. The varied topography and high relief strongly influences the precipitation pattern. In the western coastal mountain part of the basin average annual rainfall ranges from 70 to 100 inches. The central valley has 25 to 30 inches, the foothills 30 to 50 inches, and the eastern Cascade Mountains from 50 to 70 inches average annual precipitation. Rainfall intensities of four inches in one day have been recorded at Roseburg in the driest part of the basin; much higher amounts may be expected in the mountainous areas.

Streamflow is high in winter from rainfall and in spring from snowmelt, low in the dry summer season. Mean annual runoff for the Umpqua River at Elkton, about 80 per cent of the entire basin contributing, is 5,378,000 acre-feet; this is equivalent to a mean flow of 7,400 cubic feet per second. Extremes of flow at the same point have varied from 640 to 218,000 c.f.s.; from less than 10 per cent to nearly 3,000 per cent of the mean. Some of the tributaries are even more variable; - the upper South Umpqua with a mean flow of 917 c.f.s. has had a minimum of 20 c.f.s. and a maximum of 29,900 c.f.s., from 2 per cent to 3,200 per cent of the mean.

The Umpqua Basin is 88 per cent forested (1). At the higher elevations are subalpine forests of lodgepole pine, true firs, spruce, and mountain hemlock. At middle elevations are mixed conifer forests of ponderosa pine, Douglas-fir, sugar pine, and incense cedar. Around the valley in the drier areas the forest is predominantly open ponderosa pine or madrone and oak and brush. Rolling hills in the valley are in grassland, and the bottom lands are cultivated. Coast range parts of the basin are covered with a dense Douglas-fir, western hemlock, and western redcedar forest. Most of the 2,876,000 (1) acres of forest land have commercial potential. The 487,000 acres of agricultural land are three-fourths pasture land and one-fourth cropland.

Forest land is about sixty per cent in public ownership. Public lands are used primarily for timber harvest, but also for recreation. Private forest lands are also used for grazing by domestic stock. Sheep graze most of the hill pastures. Crops include corn, hay, small grains, and garden truck. The county seat, Roseburg, has a population of about 12,000; and Douglas County as a whole about 68,000. Industry is largely forest-based, Douglas County being one of the leaders in timber and lumber production.

According to the Census (3), some 32 per cent of Douglas County is agricultural land. Much of this is forested land used for pasture, since forest statistics show 83 (1) per cent of the County as commercial forest land. The cultivation of soil for pasture and crops, the harvest of timber, and the construction of roads are the major soil-disturbing land uses contributing to sediment production.

RELATED STUDIES BY OTHER AGENCIES

In a report (4) on the October 1950 floods, the Forest Service noted that the South Umpqua River carried a suspended sediment load of 6,850 ppm a day after the flood crest with streamflow at less than half the peak. The suspended sediment sampling done at several stations in the Umpqua Basin by the same agency (5) (6) through the 1950-52 seasons showed ranges of 0.2 to 10 ppm at low flow to ranges of 45 to 1600 ppm at high flow. Following the extreme flows of October 1950 the maximum values recorded for Umpqua Basin stations were from 300 to 6,850 ppm.

Anderson (7), reporting on sedimentation in the neighboring Willamette and Rogue River Basins, noted that logging and road development without preventive measures could increase sediment discharge by three times, most of the increase associated with extension of the access road system. He estimated the amount of sediment produced by eroding banks along main channels at five tons per year per running foot of eroding bank. In the upper Willamette Basin he estimated that bank erosion contributed 54 per cent of the total sediment discharge, forest land 24 per cent, and agricultural land 22 per cent.

Hayes and Herring (2) calculated from Forest Service data (6) showing the average sediment load in the South Umpqua River at 552 ppm that less than 40 per cent of the drainage basin yielded 1-3/4 million tons of sediment annually. They noted from their observations that 90 per cent of the sediment may come from 10 to 20 per cent of the watershed. They reported that the more important critical sediment source areas were roads, skidtrails, log landings, and streambanks scarred by logging.

Barton (5) reported the following summary of two years of sediment sampling in the Umpqua Basin:

Stream	Suspended Sediment Load, ppm			
	Maximum	Minimum	Average 1/	Average 2/
South Umpqua (Tiller)	850	Trace	94	49
South Umpqua (Brockway)	6,850	Trace	552	102
North Umpqua (Glide)	2,100	3	220	94
Elk Creek (Tiller)	450	Trace	106	
Little River (Glide)	777	2	104	56
Calapooya (Nonpareil)	2,930	Trace	252	61

1/ 15 samples including October 1950 peak flow
2/ 14 samples excluding October 1950 peak flow

He noted a tendency for the streams to have very high sediment loads during the months October through December, due both to high flows with flushing out of sediments dropped by receding flows of spring and summer and to caving of streambanks.

Since February 1957 the Douglas County Water Resources Board has been taking suspended sediment samples bi-weekly at ten stations in the Umpqua Basin. To date about 120 samples have been collected for each station, but unfortunately none have been taken at times of peak flow at most stations. Loads observed have ranged from 0 to 903 ppm.

Flaxman (unpublished office report) analyzed the Douglas County sampling data and ranked the different tributary watersheds according to yield. He noted the lack of sufficient peak flow data to round out the record. He also related the sediment loads to geology and soils, pointing out that the Jurassic Rogue River formation (altered lava, tuffs, and interbedded sandstones and shales) had the highest sediment production potential, and the Eocene Tyee (hard sandstones) the lowest. Eocene volcanic formations were rated intermediate.

The Forest Service pilot soil survey on the upper South Umpqua River Watershed furnished detailed information on soils and their erosion potential rated in terms of erosion hazard, slide hazard, and slump hazard. Seven soils were in the high hazard category: These are in the Deadman, Coyote, Vena, Straight, Prong, Hummingbird, and Whitehorse series. The Deadman and Straight are derived from greenish breccias and conglomerates; the Vena from acid igneous rocks; the Prong from andesites and diorites; and the Coyote, Hummingbird, and Whitehorse from basalts. Area covered by the survey included the entire upper South Umpqua Watershed north of Jackson Creek and east of Deadman Creek, in the Umpqua National Forest.

SURVEY METHODS

Surveying was done on a sampling basis by visiting as many areas as had convenient automobile access. Conditions in road ditches, road cuts and fills, stream channels, pastures, range lands, logged areas, and slide areas were observed, and the local areas given a sediment production rating of slight, low, moderate, high, or very high. Work began in the upper Cow Creek Watershed, an area known to have a very high erosion potential because of its geology - a deeply weathered granodiorite that, when stripped of its cover, melts like sugar. This area set the standard for the "very high" rating. Channel sediment deposits and the high turbidity of Cow Creek after a rain supported the rating estimate. Aerial photo mosaics were used to guide delineation of areas of similar ratings. Geologic maps were also used as a guide. The field "eyeball" ratings were finally checked against the sediment sampling data available.

The sediment production rating thus is largely subjective. It is based on field observation and interpretation of geology and soils, topography,

vegetation cover conditions, and the superposed land use in the area under study. It involves consideration also of climatic and streamflow records, sediment sampling data, and sediment deposition data.

SURVEY FINDINGS

Observed conditions varied greatly. In some cases the streams themselves seemed to provide most of their sediment load by active bankcutting. In others, eroding range and logged lands appeared to be the principal sediment contributors. In still others, slides and slumps were prime sediment sources. Everywhere, roads were a major source, though road contributions were far the greatest in the "red hill" soils areas and on the deeply weathered granodiorites.

In some areas land use appeared to be the controlling factor; in others geology and soils seemed most significant. Climate may play a part: - the western two-thirds of the basin is subject to rains of fairly high intensity, while the eastern third in the higher elevations of the Cascades receives much of its precipitation as snow. About 10 per cent of the watershed in the extreme easternmost part, the North Umpqua drainage above Toketee Falls, is covered with a highly permeable pumice soil. This area has the lowest sediment production rating of any.

Topography of the middle and upper elevations of the Umpqua Basin is rough. Slips and slides are common, particularly where timber access and other service roads traverse steep side slopes. Areas of rough topography usually show a higher rate of soil loss; however, the horizontally bedded sandstones of the western part of the basin even on the steeper slopes are erosion-resistant. On the other hand, the clayey "red hill" soils developed on the altered tuffs and breccias are highly erodible because of their tendency to slump even on the rolling topography at lower elevations.

Geology has effects both in terms of rock structure and of sediment particle size. In Cow Creek, tributary to the South Umpqua River, much of the erosion takes place on deeply weathered coarse-grained granodiorites, and the sediment is predominantly in the sand grades. Not too much of the sand fraction is caught in sampling suspended load, as the coarser sand moves by saltation along the channel bottom. Channel deposition indicated plenty of sand movement in Cow Creek, by field observation rated the greatest sediment producer of the basin. On the basis of the suspended sediment sampling records, however, Cow Creek holds only an intermediate ranking.

Land use (and abuse) is the controlling factor imposed on the landscape. Heavy and long-continued livestock grazing has in many foothill areas thinned and weakened the plant cover and compacted the surface soil; erosion and consequently sedimentation have been increased. Roads and canals, powerlines and pipelines have greatly disturbed the soil and the natural drainage pattern throughout the basin. Urban and suburban and recreation area developments locally have not only disturbed the soil but have covered

it with impermeable roots and pavement. Agriculture has changed the plant cover almost completely in the valley bottoms, in addition to disturbing the soil by cultivation. Logging has removed some of the plant cover temporarily, has disturbed the soil to some extent in some areas, and has affected runoff and drainage patterns.

Ratings given the various parts of the Umpqua Basin are as follows:

Rating	Area (by drainages)
Slight	North Umpqua above Boulder Creek
Low	North Umpqua above Glide, to Boulder Creek South Umpqua below Winston Main Umpqua (except Calapooya Creek and Elk Creek) Deer Creek near Roseburg Little River, lower half Elk Creek, central part near Drain
Moderate	Little River above Peel South Umpqua above Deadman Creek South Umpqua, from Cow Creek to Lookingglass Creek Olallie Creek above Berry Creek Myrtle Creek below Frozen Creek Elk Creek below Drain Smith River below Sisters Creek Calapooya Creek below Gassy Creek Oldham Creek below Bachelor Creek Yoncalla Creek above Yoncalla
High	Smith River above Sisters Creek Pass Creek above Fitch Creek Elk Creek above Samson Creek Oldham Creek above Bachelor Creek Calapooya above Gassy Creek Lookingglass and Olallie Creek Cow Creek below Glendale Myrtle Creek above Frozen Creek South Umpqua above Cow Creek to Deadman Creek Boze Creek, Prong Creek, and Rock Creek at head of South Umpqua
Very high	Cow Creek above Glendale Days Creek

Any tributaries not mentioned are rated with the parts of major streams where the tributaries join.

By proportion of the basin area and by weights, the ratings are as follows:

Rating	Equivalent Weight Per Unit Area	Area, %	Relative Sediment Contribution, %
Slight	1	9	1
Low	3	33	7
Moderate	9	27	18
High	27	27	52
Very High	81	4	22
		100	100

Special problem areas could include any of those given a "high" or "very high" rating, or 30 per cent of the entire basin. Yet some problem areas are of little significance except in reservoir sedimentation because the sediments produced are trapped behind dams and do not affect long reaches of stream. Reasons for existence of the problems vary. Days Creek suffers severe bankcutting along much of its length. Calapooya Creek suffers severe bankcutting plus logging damage on its watershed. Cow Creek has suffered from careless treatment of the delicately balanced unstable granodiorite-based soils in the upper watershed, from considerable soil disturbance by road-building and logging and from some bankcutting in the lower watershed. The upper Smith River Watershed suffers from excessive soil disturbance by road-building and logging on very rough topography, and a large amount of logging debris has been left in the channels of many of the tributaries.

DISCUSSION

Though the ratings were guided to some extent by the suspended sediment sampling data, there is no good correlation between them. The sediment data were recognized as incomplete, both as to size of sediment particle and size of flow sampled. For example, Steamboat Creek (a North Umpqua River tributary in the high mountains with fairly good watershed conditions) showed by the sediment sampling about one-fourth the average sediment load sampled in Calapooya Creek (a foothill tributary with a badly abused watershed and plenty of channel indications of considerable sediment movement). These watersheds are of comparable size; the field rating put the sediment contribution from Steamboat Creek at only one-twentieth of that from Calapooya Creek. Steamboat Creek had been sampled a couple of times at very high flow stages, while Calapooya Creek had not been sampled at much above mean flow.

Analysis of the sampling shows that the low frequency high flows carry a disproportionate - and the major - share of the sediment load. About seven per cent of the flows sampled carried 28 per cent of the average sediment

concentrations observed; combining flow times sediment concentration, this seven per cent of high flows then carried about 90 per cent of the total sediment load.

Some high sediment concentrations were noted at times of average to low flow; these were due to mining, roadbuilding, and gravel-washing operations.

Mechanically-patterned sampling on a bi-weekly schedule though providing 120 samples per station in four years and a half did not cover the range of streamflow occurrences needed for a complete picture. Low flow conditions are plentifully represented, but the significant high flow conditions are not represented at all at some stations. Either a total of fifteen to twenty years of sampling, or special attempts to sample at times of high flow will be needed. Cooperation with the Douglas County Water Resources Survey has been established to get high flow samples this coming wet season.

RECOMMENDATIONS FOR IMPROVEMENT (2), (8), (9), (10)

Where soil and channel conditions are naturally unstable, avoidance of undue disturbance will prevent large increases in erosion and sediment production. In the granodiorite areas, it is possible to build roads and harvest the timber without abusing the land; disposal of road drainage at frequent intervals, dispersal of drainage in contour infiltration trenches, high-lead cable logging instead of tractor logging, restricted use of skidtrails to prevent deep gouging, installation of waterbars for drainage diversion in abandoned skidtrails and spur roads, mulching and seeding cut and fill slopes, and immediate replanting of cutover areas all will help keep erosion and sediment production at a low level. In the "red hill" soil areas where there is a persistent tendency for the land to slump and slide, the less road-building disturbance the better. Where roads are necessary, the penalty of increased erosion and sedimentation must be accepted.

Road maintenance is a common source of stream turbidity and sediment in the Umpqua Basin. Overcasting of excess material from ditches and road surfaces directly into stream channels appears to be a regular practice. This practice should be stopped; the excess material should be end-hauled to a location where it will not directly damage the streams and where it can be stabilized. The same recommendation applies to road construction.

In laying out timber harvest operations, the road system should be planned for the minimum necessary. Cutting areas should not be laid out across streams, and where there is little danger of windthrow cutting boundaries should leave a protective strip of trees along streams to provide shade and to trap debris from slopes above. Uphill cable logging should be planned wherever possible. Logs should be swung across channels, not dragged across. Landings should be located away from channels; both landings and skidtrails should be drained to places where water can infiltrate safely into the soil. Repeated use of the same skidtrails should be limited, and tractor yarding stopped when the soil is wet. Timber should

be felled upslope away from channels, and logging slash kept out of channels. Channel crossings should be on temporary culverts to be carefully removed when the work is finished. Digging gravel for road surfaces from live streams should not be permitted.

Quarry and mine drainage should be diverted to infiltrate into the soil away from streams. Waste piles should be located so that they will not erode into streams.

Channel banks subject to cutting should be protected with riprap and planted to willows and alder. Channel cutoffs and diversions should be avoided wherever possible; encroachment of road fills on channels should also be avoided.

Burned areas should be seeded with quick-growing cover crops and planted to trees to prevent excessive erosion, loss of productive capacity, and sedimentation.

Unstable debris accumulations in channels should be cleaned out.

Erosion "sore spots" that persist and do not heal should be treated. Drainage diversion, contour furrowing, staking and mulching, seeding and planting are useful methods.

Grazing on hill lands should not be permitted to the point that cover density is reduced below 70 per cent.

Cultivation of sloping land should be on contour, in strips with bands left in full cover between to trap runoff and sediment. Irrigation should be done in such a way that waste waters do not cause erosion.

BIBLIOGRAPHY

(1) "Umpqua River Basin"; State Water Resources Board, July 1958

(2) "Some Water Problems and Hydrologic Characteristics of the Umpqua Basin", G. L. Hayes and H. G. Herring, July 1960, PNW Forest and Range Experiment Station

(3) Census of Agriculture 1960

(4) "Floods of October 1950 in Southern Oregon", Office Report, PNW Forest and Range Experiment Station, 1951

(5) "Progress Report on Suspended Sediment Sampling in Several Western Oregon and Western Washington Streams", by Manes Barton, Research Note No. 75, PNW Forest and Range Experiment Station, 1951

(6) USDA Flood Control Survey Stream Sediment Sampling Record, Mimeographed Monthly November 1950 to July 1952, PNW Forest and Range Experiment Station

(7) "Suspended Sediment Discharge as Related to Streamflow, Topography, Soil and Land Use", H. W. Anderson, Transactions AGU Vol. 35 No. 2, April 1954

(8) "Some References on Watershed Management", by W. E. Bullard, Research Note No. 63, PNW Forest and Range Experiment Station, 1950

(9) "Watershed Protection - A Manual for Forest Landowners", Water Management Committee, Columbia River Section, Society of American Foresters, 1961

(10) Forest Service Handbook, Title 2500 - Watershed Management, and 2533 - Land Treatment Measures, 1959